

CLAIMS

1 1. A method for transmitting a plurality of pre-coded programs having different bit
2 rates across a fixed bandwidth channel, comprising the steps of:
3 generating at least two different bit rate representations of each program;
4 providing control information at each of a plurality of successive time windows T for
5 each representation of each program, the control information for each successive window
6 indicating a bit rate and quality measure for a representation of a corresponding program; and
7 during each time window T, selecting a representation for each program such to
8 maximize the quality of the selected representations while not exceeding a total available
9 capacity for the channel.

1 2. The method according to claim 1 wherein the step of generating at least two
2 different bit rates representation further comprises the step of generating for each program a
3 lowest bit rate representation having a peak bit rate not greater than C/P where C is the total
4 channel capacity in time T and P is the total number of programs.

1 3. The method according to claim 1 wherein the step of providing the control
2 information further comprises the step of establishing the peak signal-to-noise ratio (PSNR) as
3 the quality measure embodied in the control information.

1 4. The method according to claim 1 wherein the selecting step further comprises the
2 step of selecting a representation for each program which meets the constraint

$$\sum_{p=0}^{P-1} r[p, n[p]] \leq C \text{ for all time windows wherein:}$$

4 C is the total channel capacity available in time frame T;
5 P is the total number of programs;
6 $p \in (0, P-1)$, is the index of a particular program;
7 $N[p]$ is the total number of representations of program p;
8 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p; and
9 $r[p, x]$ is the bit rate of representation x of program p during T

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1 5. The method according to claim 4 further comprising the step of choosing each
2 program's representation $n[p] \in (0, N[P]-1)$ to maximize the quality of the program p that had
3 the minimum quality.

1 6. The method according to claim 5 further comprising the steps of:
2 (a) sorting the quality information for with the bit rate and quality measure monotonically
3 increasing with an index value;
4 (b) storing each bit rate increment (delta) and quality value for each index value;
5 (c) beginning with a lowest index value, computing total capacity S for program
6 representations selected thus far for such index value;
7 (d) selecting a program representation at a lowest quality measure;
8 (e) checking whether the bit rate increment of the selected program at the lowest quality,
9 when added to the representations selected thus far, exceeds total channel capacity, and if not
10 (f) incrementing the index value; and
11 (g) repeating steps (c)-(f).

1 7. The method according to claim 1 wherein the selecting step further comprises the
2 step of selecting the representation for each program such to maximize a sum of individual

3 program qualities by solving $\max_{n[\cdot]} \sum_{p=0}^{P-1} q[p, n[p]]$; subject to $\sum_{p=0}^{P-1} r[p, n[p]] \leq C$

4 wherein,

5 C is the total channel capacity available in time frame T ;

6 P is the total number of programs;

7 $p \in (0, P-1)$, is the index of a particular program;

8 $N[p]$ is the total number of representations of program p ;

9 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p ;

10 $r[p, x]$ is the bit rate of representation x of program p during T ; and

11 $q[p, x]$ is the quality of representation x of program p during T .

1 8. The method according to claim 1 wherein the selecting step further comprises the
2 step of selecting the representation for each program such to maximize a product of individual
3 program qualities by solving

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$$4 \quad \max_{n[p]} \prod_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

- 5 where,
- 6 C is the total channel capacity available in time frame T ;
- 7 P is the total number of programs;
- 8 $p \in (0, P-1)$, is the index of a particular program;
- 9 $N[p]$ is the total number of representations of program p ;
- 10 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p ;
- 11 $r[p, x]$ is the bit rate of representation x of program p during T ; and
- 12 $q[p, x]$ is the quality of representation x of program p during T .

1 9. The method according to claim 8 further comprising the step of applying a
2 weighted average to provide different classes of service for different viewers.

1 10. A system for transmitting a plurality of pre-coded programs having different bit
2 rates across a fixed bandwidth channel, comprising the steps of:
3 means for generating at least two different bit rate representations of each program;
4 means providing control information at each of a plurality of successive time windows T
5 for each representation of each program, the control information for each successive window
6 indicating a bit rate and quality measure for a representation of a corresponding program; and
7 means for selecting during each time window T a representation for each program such to
8 maximize the quality of the selected representations while not exceeding a total available
9 capacity for the channel.

1 11. The system according to claim 10 wherein the generating means and control
2 information providing means collectively comprise:
3 a plurality of multirate stream generators, each associated with a corresponding one of the
4 plurality of pre-coded programs.

1 12. The system according to claim 10 wherein the generating means and control
2 information providing means collectively comprise:
3 a multirate video encoder for encoding at least two bit rate representations of each pre-
4 coded program.

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- 1 13. The system according to claim 10 wherein the generating means and control
- 2 information providing means collectively comprise:
 - 3 a multirate video encoder for encoding at least two bit rate representations of each pre-
 - 4 coded program; and
 - 5 a plurality of transport packetizers, each serving to packetize the bit rate presentations for
 - 6 each pre-coded program.

- 1 14. The system according to claim 10 wherein the selecting means includes a static
- 2 multiplexer.

- 1 15. The system according to claim 12 wherein the selecting means comprises:
 - 2 a static multiplexer; and
 - 3 a transport packetizer for packetizing the selecting representation.

- 1 16. The system according to claim 10 wherein the selecting means generates for each
- 2 program a lowest bit rate representation having a peak bit rate not greater than C/P where C is the
- 3 total channel capacity in time T and P is the total number of programs.

- 1 17. The system according to claim 10 wherein control information providing means
- 2 establishes quality measure in accordance with a peak signal-to-noise ratio (PSNR).

- 1 18. The system according to claim 10 wherein the selecting means selects a
- 2 representation for each program which meets the constraint $\sum_{p=0}^{P-1} r[p, n[p]] \leq C$ for all time
- 3 windows where:
 - 4 C is the total channel capacity available in time frame T ;
 - 5 P is the total number of programs;
 - 6 $p \in (0, P-1)$, is the index of a particular program;
 - 7 $N[p]$ is the total number of representations of program p ;
 - 8 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p ; and
 - 9 $r[p, x]$ is the bit rate of representation x of program p during T .

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1 19. The system according to claim 18 wherein the selecting means chooses each
 2 program's representation $n[p] \in (0, N[P]-1)$ to maximize the quality of the program p that had
 3 the minimum quality.

1 20. The system according to claim 10 wherein the selecting means selects the
 2 representation for each program such to maximize a sum of individual program qualities by
 3 solving:

$$4 \quad \max_{n[p]} \sum_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

5 where,

- 6 C is the total channel capacity available in time frame T;
 7 P is the total number of programs;
 8 $p \in (0, P-1)$, is the index of a particular program;
 9 $N[p]$ is the total number of representations of program p ;
 10 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p ;
 11 $r[p, x]$ is the bit rate of representation x of program p during T; and
 12 $q[p, x]$ is the quality of representation x of program p during T.

1 21. The system according to claim 10 wherein the selecting means selects the
 2 representation for each program such to maximize a product of individual program qualities by
 3 solving:

$$4 \quad \max_{n[p]} \prod_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

5 where,

- 6 C is the total channel capacity available in time frame T;
 7 P is the total number of programs;
 8 $p \in (0, P-1)$, is the index of a particular program;
 9 $N[p]$ is the total number of representations of program p ;
 10 $n[p] \in (0, N[p]-1)$ is the index of a particular representation of program p ;
 11 $r[p, x]$ is the bit rate of representation x of program p during T; and
 12 $q[p, x]$ is the quality of representation x of program p during T.

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- 1 22. The system according to claim 10 wherein a weighted average is applied to
2 provide different classes of service for different viewers.

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